



Review of Recent Significant Technologies and Initiatives Implemented to Enhance Navigational Safety and Protect the Marine Environment in the Straits of Singapore and Malacca

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The Straits of Singapore and Malacca is among the busiest waterways in the world and recognised as a waterway used for international shipping. It is along the shortest route between Europe and East Asia via the Suez Canal. These Straits are important as many countries depend on them for unimpeded navigational access for trade and transit.

Physically, the combined length of the Singapore and Malacca Straits is about 580 nautical miles and the narrowest width is off the southern tip of Singapore where it is slightly more than a kilometre. Numerous shoals and other navigational hazards exist in the Singapore and Malacca Straits. Aids to navigation are installed to mark these dangers and demarcate the deep water route of the minimum 23 metres depth. Most of the vessels with deeper drafts are obliged to use the deeper, but considerably longer, passage through the Sunda Strait.

The issue of navigational safety within these straits is of concern to the littoral states of Indonesia, Malaysia and Singapore. Within the Singapore Strait, about 1,000 vessels report daily to the Port Operation Control Centre (POCC) and with the heavy traffic any major accident would affect port operations, marine activities and the marine environment. Coupled with the high percentage of marine accidents attributed to human error, the littoral states regularly review, consult, improve and implement measures to enhance navigational safety in these busy waterways.

The experience of three major oil spills in the Straits¹ over the last 25 years has instilled into the littoral states the need to adopt a proactive approach to enhance navigational safety and to prevent marine environment disaster.

This paper examines the coordinated efforts and contributions by the littoral states to enhance navigational safety in the Straits of Singapore and Malacca. It also focuses on the technologies implemented for precise navigation and to further improve information communication flow between vessels and the shore-based centres, in particular by the Port of Singapore.

¹ Grounding Showa Maru in 1975 (3,300 tons spilled), Collision between Evoikos and Orapin Global in 1997 (28,500 tons spilled) and grounding of Natuna Sea in 2000 (7,000 tons spilled).

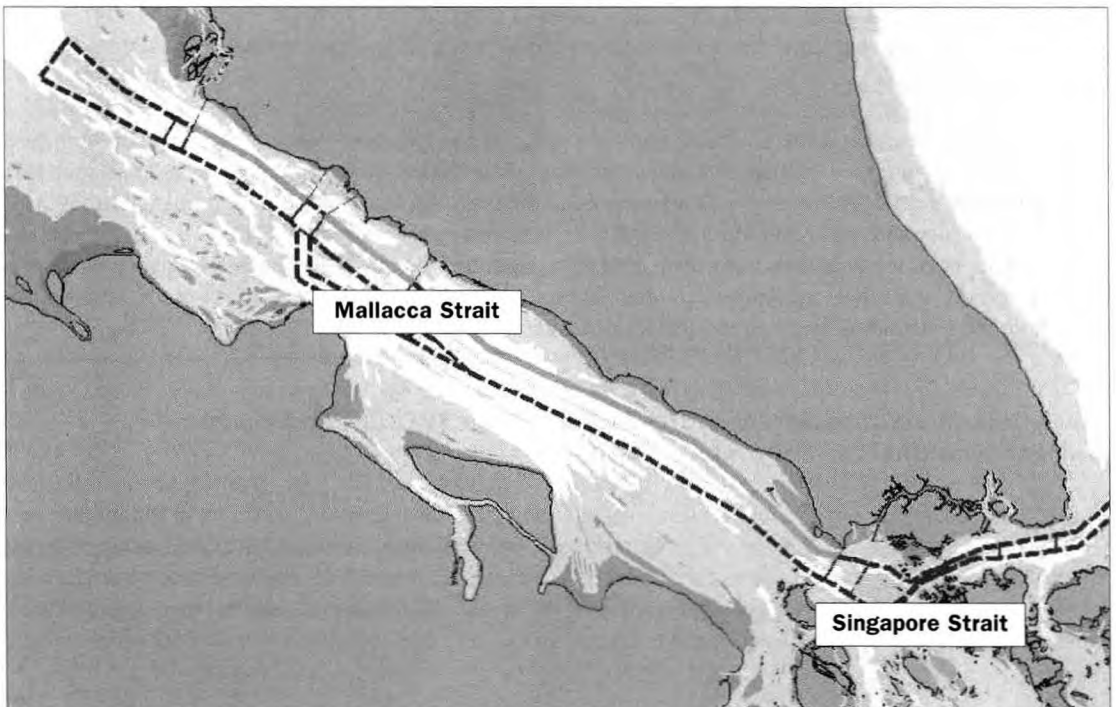
Tripartite Technical Experts Group (TTEG)

In the early 1970s, the governments of the littoral states agreed to form a body to coordinate efforts to enhance the safety of navigation in the Straits of Singapore and Malacca. The agreement led to the formation of the Tripartite Technical Experts Group (TTEG) in 1975, which comprises officers from the Maritime and Port Authorities and Hydrographic Offices. The TTEG has made significant strides in the enhancement of navigational safety in the Straits. Many people in the shipping community have and continue to recognise that the TTEG plays an essential role in maintaining maritime safety for these two waterways.

The littoral states recognise the International Maritime Organisation (IMO) as the international authority on shipping and all are signatories to the Safety of Life at Sea Convention (SOLAS). It is consulted on proposals affecting international shipping using the Straits. For example, the IMO has been consulted on the establishment of the Routing System covering a traffic separation scheme (TSS) for the safe navigation of deep draft vessels at the One Fathom Bank off Port Klang, the Singapore Strait, and off Horsburgh Lighthouse. Within the TTEG, the process for the proposal required the drafting and promulgation of rules for navigation, harmonising the chart datum of the three states, and the conduct of hydrographic surveys, including tidal and current observations.

It was through close co-operation of the three states, and with financial and technical assistance from Japan, which is a major user of the straits, that the Routing System was developed. On 14th November 1977, the erstwhile Intergovernmental Maritime Consultative Organisation (IMCO) Assembly adopted a resolution which established the Routing System in the Straits. It was successfully implemented in May 1981.

In 1998, the Routing System was extended and amended. The revised Routing System was adopted by the IMO Maritime Safety Committee in May 1998 in accordance with the provisions of resolution A.858(20) and came into force in December 1998.



Straits of Singapore and Malacca

Other recent milestones achieved by the TTEG include the implementation of STRAITREP, which is a mandatory ship reporting system, and a Four-Nation Re-Survey of Critical Areas and Investigation of Dangerous/Unconfirmed Shoals and Wrecks in the Straits.

The maintenance of safety of navigation in the Straits remains one of the key challenges of the TTEG as traffic in the Straits is one of the busiest in the world. This would impose a greater burden on the littoral states in ensuring navigational safety and the protection of the marine environment.

Based on past records, users of the Straits would be pleased to know that the IMO and other relevant international authorities such as the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) would be consulted on proposals affecting navigation in the Straits, including the use of technologies to enhance navigation safety.

Highlight on Recent Technologies Implemented in the Straits

Besides measures such as mandatory reporting and the extension of the TSS, the use of the latest technologies has been one of the main instruments used by Singapore to cope with the high traffic density and confined waters in the Straits. Some examples of the technologies are:

Differential Global Positioning System (DGPS)

In October 1997, Singapore set up facilities to broadcast differential global positioning system (DGPS) corrections to provide higher order and consistent positional accuracy.² Singapore continues to maintain the DGPS service so as to provide positional accuracy of $\pm 10\text{m}$ even with the announcement by the US to remove the selective availability (SA) on global positioning system (GPS) with effect from 1st May 2000. The U.S. Department of Commerce issued a statement on the same day that with the removal of SA, the accuracy of the GPS has improved from ± 100 metres to ± 20 metres, 95 per cent of the time. This does not meet the IMO's specification of within ± 10 metres within a 95 per cent probability, as stated in resolution A.815(19).

High positional accuracy of DGPS is obtained by measuring the difference between the signals from GPS satellites with a reference station at a known position. The DGPS correction values are determined and sent to vessels with DGPS receivers. These correction signals are transmitted on the medium frequency. The DGPS corrections are transmitted without charge to the maritime community and could be received at a distance of at least 200km from Singapore. The accurate positions are especially important for precise navigation, especially in shallow confined waters and in areas where the littoral states share common maritime boundaries such as the Straits of Singapore and Malacca.

Electronic Chart Display and Information System (ECDIS) and Electronic Navigational Chart (ENC) Data

ECDIS is an advanced ship-borne electronic navigational tool for improving navigational safety and preventing marine accidents. It could be integrated with sensors such as the GPS/DGPS, echo sounder, speed log and gyrocompass for the conduct of safe navigation. The ECDIS uses electronic navigational charts (ENC), which provide a geographical information system (GIS) meeting very detailed specifications provided by the International Hydrographic Organisation (IHO) containing charted and relevant nautical

² MPA website at '<http://www.mpa.gov.sg/homepage/services/dgps.html>'

information produced or authorised by national Hydrographic Offices. The IMO adopted the performance standards for ECDIS and approved it as a paper chart equivalent since November 1995.³

When integrated with the GPS/DGPS, the ECDIS can provide 24-hour real-time positioning and navigation assistance under all weather conditions, thus preventing accidents such as grounding which could cause marine pollution. The automatic real-time updating of the ship's positions on the ECDIS allows the mariner more time to keep a vigilant visual look out instead of being buried in chart work. It can also be integrated with an Automatic Radar Plotting Aid (ARPA) to provide anti-collision audio or visual alarms.

The ECDIS is especially effective in confined waters such as the Straits, where the traffic density is heavy and poor visibility during haze condition when there are forest fires or during adverse weather conditions.

Vessel Traffic Information System

In October 1990, a radar-based tracking system known as the vessel traffic information system (VTIS) was set up to monitor the traffic in the Singapore Strait. Incorporated into the VTIS was a voluntary reporting system for vessels transiting the Strait. About 85 per cent⁴ of the vessels participated in the reporting system.

The VTIS and the reporting system were useful as they facilitated the exchange of essential traffic information to other vessels. For example, -VTIS would generate timely alerts to vessels that are heading into dangers, thereby preventing accidents. Last year, the Maritime and Port Authority of Singapore completed a US\$12 million programme to upgrade the existing VTIS at the Tanjong Pagar POCC and a new POCC established at PSA Vista, which is fully equipped with a state-of-the-art VTIS. In both systems, the Singapore ENC is used as an underlay for the plots of vessels' tracks.



Port Operations Control Centre

Automatic Identification System (AIS) Transponder

The IMO Maritime Safety Committee adopted the performance standard for a universal automatic Identification System (AIS) transponder at its 69th session in May 1998 by resolution MSC.74(69). The AIS transponder implementation would be in phases with the first phase commencing on 1st July 2002. Vessel's positions in the AIS transponder are derived from the vessel's GPS receiver. Vessels equipped with AIS transponders facilitate easy identification and exchange of information such as position, speed, course and other data between vessels and with VTIS centres. The AIS transponder would also prevent mistaken identity in a radar-based system, which has a risk of 'target swap'. In addition, the port authority could easily identify and respond quickly to the vessel involved in potential emergency situations.

Singapore successfully conducted a pilot test on the AIS transponders from April to June 1999⁵ to evaluate the performance and effectiveness of AIS transponders in enhancing navigational safety. Integrating the AIS transponders as one of the sensors to the ECDIS would be evaluated next. With the integration, the AIS transponders would provide value-added information and assistance to the mariners. It could present situational pictures showing the locations and identity of other vessels equipped with AIS transponders and at the same time ascertain the navigable waters and the dangers within the vicinity. As both the ECDIS and AIS transponder would most probably be sharing a common GPS or DGPS receiver, the possibility of positioning or geodetic datum errors would also be minimised.

³ IMO Resolution A.817(19) adopted on 23 November 1995.

⁴ Mark Heah, Implementation of Mandatory Ship Reporting in the Malacca and Singapore Straits, Singapore and Maritime & Port Journal 2000, Maritime and port Authority of Singapore, pp84, Y2000.

⁵ Teo Chee Beng & Jamie Chen, Application of Satellite Navigation and Communication Technologies for the Port of Singapore, Singapore and Maritime & Port Journal 2000, Maritime and port Authority of Singapore, pp93, 94, Y2000.

The integration of AIS with ECDIS would improve the confidence level of mariners as it reduces voice communication and facilitate safe movements in the Straits.

Initiatives to Complement the Technologies

Mandatory Ship Reporting System in the Straits of Malacca and Singapore (STRAITREP)

The STRAITREP was drawn up by the three littoral states in accordance with the IMO guidelines and criteria.⁶ The objectives are to:

- Enhance safety of navigation
- Protect the marine environment
- Facilitate movements of vessels
- Support the Search and Rescue (SAR) and Oil Pollution response operation

The operational area of the STRAITREP covers the Straits of Malacca and Singapore between 100° 40 minutes east and 104° 23 minutes east. It is further divided into nine sectors and each sector is assigned with a VHF channel. Integrated with the VTIS, the STRAITREP provides information to vessels on specific and critical situations that concerns navigational safety at no cost to the users. The STRAITREP was adopted at the 69th session of the IMO Maritime Safety Committee in May 1998 and put into force on 1 December 1998. Since its implementation, Singapore receives about 30,000 reports each month from vessels transiting and calling at the Port. With the STRAITREP, the Authorities have been able to provide traffic information, navigational assistance / advice and assistance in the coordination of search and rescue.

Marine Electronic Highway (MEH) for the Straits

The first phase of the regional MEH has been approved by the Global Environment Facility for implementation in 2001⁷. A grant of US\$350,000 has been provided for the development of a project brief. The World Bank and the IMO have been appointed the project Implementing Agency and Executing Agency, respectively.

The purpose of the MEH project is to use innovative technological tools to create, network and maintain a marine information infrastructure that would benefit public and private sector stakeholders. The project aims to develop essential tools for marine pollution prevention and control, marine environmental planning and management, and navigational safety.

The first Project Steering Committee comprising members from the three littoral states and IMO representatives was held in March 2001. Discussion was focussed on the implementation of the MEH such as the establishment of international and in-country management framework, including the organisation of national and regional workshops. Singapore will be hosting a regional workshop whereby, a Regional Action Plan would be formulated taking into consideration the respective national plans.

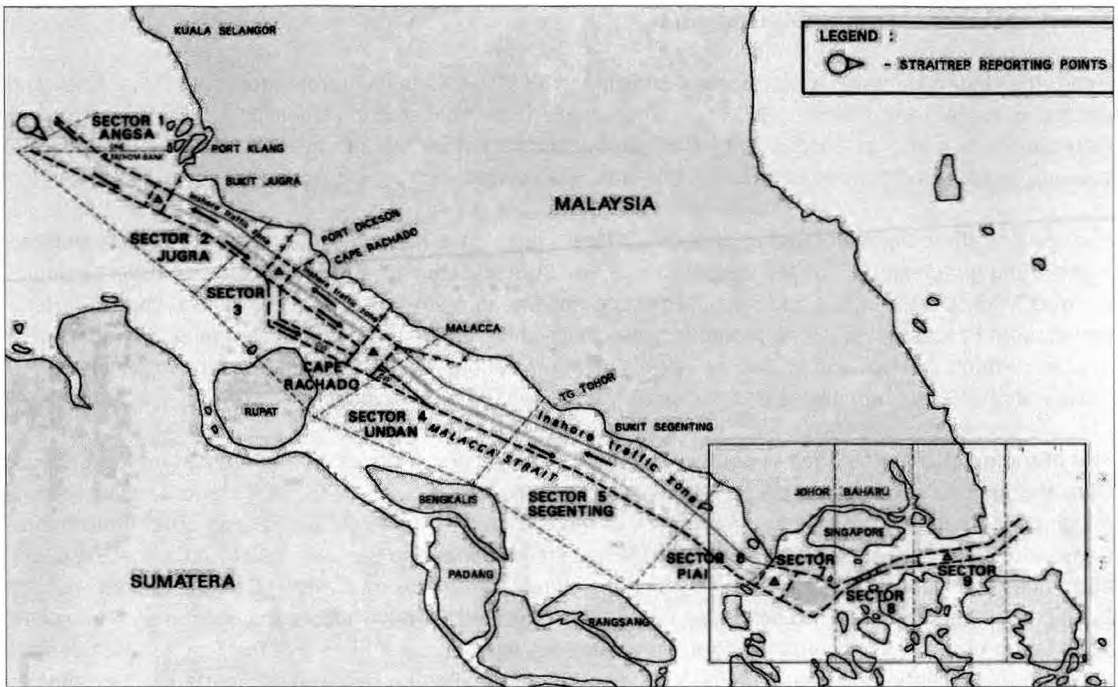
SHARED Programme

In March 1997, MPA and the United Kingdom Hydrographic Office collaborated to demonstrate the use of the world's first combined ENC/RNC (Raster Navigational Charts) database with ECDIS on board three international container vessels: the 'Katrine Maersk', the 'Sovereign Maersk' and the P&O NedLloyd 'Shenzen Bay.' The demonstration covered the shipping routes between Southampton and Hong Kong via Singapore. The demonstration was then called **S**ingapore, **H**ong Kong, **A**dmiralty **R**aster and **E**NC **D**emonstration. Besides the Hydrographic Offices (HOs) of the United Kingdom and Singapore, the HO of Hong Kong SAR also participated in the initial demonstration⁸.

⁶ IMO Resolution MSC. 43(64) – Guidelines and Criteria for Ships Reporting System.

⁷ IMO News, First phase of East Asia's Marine Electronic Highway takes off, IALA Bulletin 2001/2, pp 32, Y2001.

⁸ Chua Wilson, The SHARED Programme: A Viable Model for the Global Promotion of ECDIS with Official Electronic Charts, Port of Singapore, The Maritime Hub – Maritime R & D and Technology – New Frontiers, pg 13. December 2000.



Operation area of the STRAITREP

The main objective of this demonstration was to assess the safety, effectiveness and usefulness of integrated ENC and RNC with ECDIS for safe navigation. Additionally, it also aimed to demonstrate the practical exchange of electronic hydrographic data between national HOs. The demonstration has proven to be successful as well as useful that the ECDIS initially installed are still on board two vessels and invaluable feedback from these ships is still being received.

With the success of the demonstration, the SHARED concept has appealed to more HOs. The demonstration was extended to more HOs and renamed the SHARED Programme with the first informal SHARED Programme Meeting held in January 1998 in Singapore. The HOs participating in the Programme has increased in number to more than ten. They are HOs from Australia, Canada, Chile, China, Hong Kong SAR, Indonesia, Japan, Malaysia, Philippines, South Korea, the United Kingdom, the United States of America and Singapore. With more demonstration projects extending to other parts of the world, several other HOs have expressed interest in participating in the SHARED Programme.

In May 2000, the SHARED Programme extended its demonstration beyond commercial shipping vessels. The Republic of Singapore Navy vessel 'RSS Endurance' was fitted with a locally developed ECDIS and official ENC and RNC for her circumnavigation of the world. Through the SHARED Programme, the framework for the integration and delivery of official chart data covering the entire round the world route of 'RSS Endurance' were provided and integrated. ENC and RNC were provided by Canada, Indonesia, Malaysia, United States of America, United Kingdom and Singapore.

SHARED Programme Round-the-world Demonstration

The SHARED Programme recognises that the strength of ECDIS lies not only in its GIS capability but also in its versatility to be used for other applications in any country where IHO S57 data is available. The ECDIS technology provides a framework and platform for other navigational and non-navigational products. However, the priority task identified during the SHARED programme meetings was to increase the maritime community's awareness of sources of official data, distributors and ECDIS manufacturers. In this respect, Singapore has been tasked to establish a web-site to serve this purpose.

Meeting International Obligations

Under the United Nations Law of the Sea Convention 1982 (UNCLOS), littoral states with rights to extended sea space ie. territorial sea, EEZ or continental shelf, are obligated to (Article 194(1)) undertake either "individually or jointly as appropriate, all measures consistent with this Convention that are necessary to prevent, reduce and control pollution of the marine environment from any source".

Recognising the obligations under UNCLOS, littoral states face problems with surveillance and enforcement of the large expanse of sea space. Hence, the littoral states have turned to the use of technologies such as VTIS, DGPS, ECDIS and satellite remote imaging to meet these obligations. The combined technologies and measures such as mandatory reporting have resulted in better coverage and effectiveness in enforcement. Examples of technologies applied in the various areas of the marine industry such as fisheries where AIS transponders are installed onboard licensed fishing vessels.

Two of the practical difficulties of detecting illegal discharge from vessels are night time and the distance from the shore. To overcome these difficulties, technologies such as VTIS, DGPS and satellite remote imaging play a major role in the enforcement of requirements of MARPOL 73/78 and other international Conventions. For example, a significant achievement was made in January 1997 when the Singapore authorities successfully prosecuted a Singapore registered vessel, 'Song San' anchored outside Singapore waters for illegally discharging oil and polluting Singaporean waters and coastline⁹. The owners and Master of the vessel were also charged under the Prevention of Pollution of the Sea Act. Besides evidence from conventional investigations, VTIS display and satellite images were submitted to the Court as evidence identifying the vessel 'Song San' deliberately discharging oil into the sea in mid-August 1996 under the cover of darkness. Oil samples from the vessel were subsequently taken from the vessel and found to match the samples taken from the surrounding waters.

In considering the sentence, the Court took into account several factors. The owners and vessel had not maintained the mandatory oil record books of the vessel as required under Annex 1, Regulation 20 (Oil record book) of MARPOL 73/78. The offences were aggravated by the fact that Singapore is the world's busiest port, and being strategically located makes it particularly vulnerable to pollution. In addition, the increasing marine and leisure activities raised the need to keep the waters pollution free. More importantly, the offences were committed in total disregard of any concern for the marine environment.

The use of technologies extends beyond navigational safety and emphasizes the need to be prepared and ready to combat oil spills. Indonesia, Malaysia and Singapore are members of the Oil Spill Preparedness and Response (OSPAR) project with technical assistance and equipment supplied by Japan. In addition, a Revolving Fund was established for the Singapore and Malacca Straits in 1981.¹⁰ It is a reserved fund provided by Japan for use in clean-up operations.

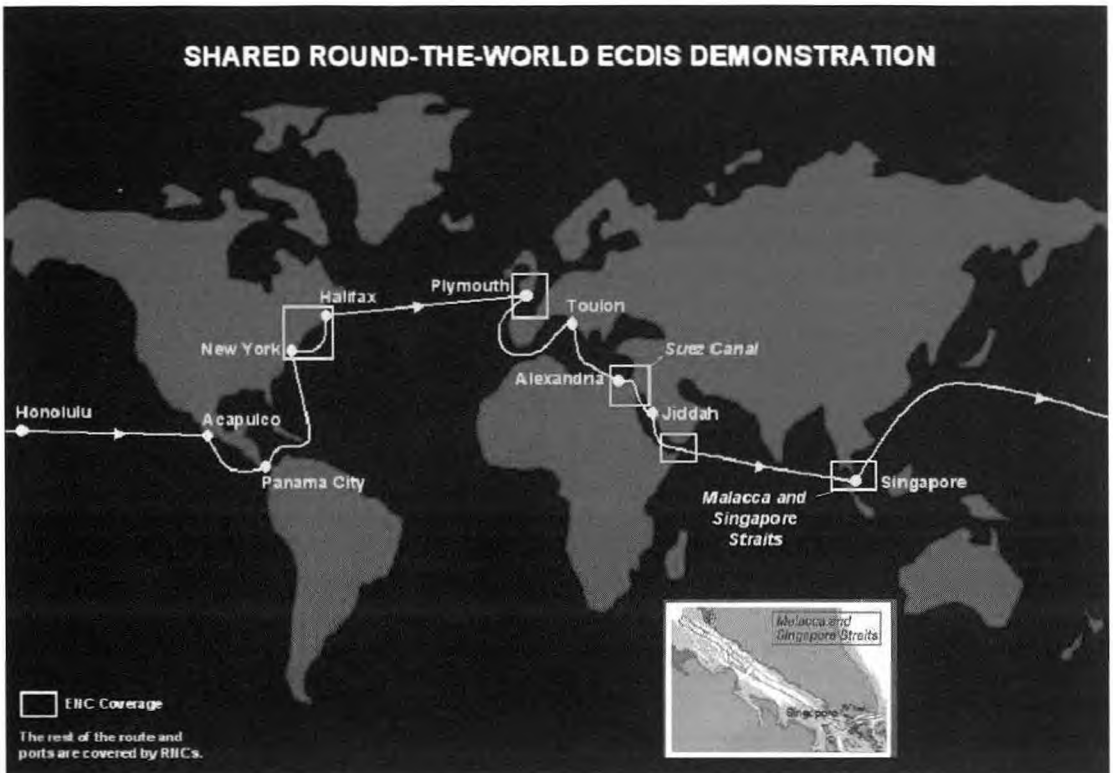
Main Benefits of Technologies and Initiatives to Users and Littoral States

The technologies and initiatives that have been implemented in the Straits have been in conformance with international conventions, guidelines and standards specified by the UNCLOS, IMO, IALA and the International Hydrographic Organisation (IHO).

Some of the main benefits derived from the technologies and initiatives that have implemented for the Straits to enhance navigational safety and protect the marine environment are:

⁹ Zafriul Alam, MPA-Maritime Environment Regulatory Functions and Issues, Singapore Maritime & Port Journal 1998, Maritime & Port Authority of Singapore, pp 53, 1998

¹⁰ Hamzah & Mohd Nizam Basiron, The Straits of Malacca: Some Funding Proposals, MIMA Paper – Maritime Institute of Malaysia, pp25 & 26, 1996.



Shared Round-the-world ECDIS demonstration

- Availability of continuous high positional accuracy of ± 10 metres under all weather conditions provided by the DGPS for precise navigation
- Adoption of standard geodetic datum for charting and positioning system such as the ECDIS and DGPS i.e. local datum is replaced with the World Geodetic System 1984 (WGS 84)
- Increase mariners' confidence in navigating in confined waters through the use of ECDIS / ENC for route planning, monitoring and displaying of chart information
- Reduction in voice communications with the aid of the VTIS as vessels are automatically tracked, which facilitates easier identification and dissemination of information / warning to vessels heading into danger. Voice communication could be further reduced with AIS
- Provision of updated hydrographic information on shoals, wrecks and obstructions in the Straits
- Clearly defined east and west bound traffic routes throughout the entire stretch of the Straits
- Provision of traffic and navigational assistance and advice to vessels
- Prompt assistance in the co-ordination of search and rescue

The technologies and initiatives implemented have been transparent to the users. More importantly, the right of navigation through the Straits has never been undermined or compromised.

Concept of Burden Sharing

Presently, the maintenance of aids to navigation, conducting of hydrographic surveys and combating of oil spills rest mainly with the littoral states bordering the Singapore and Malacca Straits. Although Article 43 of the United Nations Law of the Sea Convention (1982) urges User States and States bordering a strait to co-operate in the establishment and maintenance of necessary navigational and safety aids, to date only Japan has been providing some funding to support these activities.

The rising number of marine accidents and pollution in the busy waterways used by international shipping has led to some littoral states advocating the concept of burden sharing. In a study conducted by the Sakura Institute of Research in 1999 on the traffic flows in the Straits of Malacca and Singapore¹¹, it quoted International Monetary Fund statistics linking growth rates of economies in the region to trade trends. It argued that based on the research and statistics, littoral states could justifiably seek funding support to defray the costs of these services provided to users of the Straits.

Singapore together with the IMO has taken the initiative to jointly organise international conferences¹² to identify and discuss possible models for burden sharing. Whilst this issue is being debated, apart from the contributions made by Japan, the littoral states are left with the burden of funding the maintenance of services essential for safe navigation.

Conclusion

Enhancing navigational safety and protecting the marine environment are major challenges for the littoral states in the Straits. Recognising that there is an urgent need to reduce the risk of marine incident in the area of high traffic density and confined waters, littoral states in the Straits have cooperated and implemented several major initiatives such as TSS, STRAITREP and hydrographic surveys. At the same time, there has also been investment into technologies such as VTIS, ECDIS, ENC and DGPS to facilitate vessels' safe navigation. In the process of implementing the technologies or initiatives, the littoral states have always recognised and consulted the IMO and other international authorities on issues affecting users of the Straits.

The implementation of these technologies and initiatives is aimed at providing better positional accuracy and chart information for navigation. Furthermore, it facilitates timely exchange of information between vessel and shore-based centres. All these have benefited both the users and the littoral states

The investment in technologies and initiatives is to enhance navigational safety and protect the marine environment that benefits both the users and littoral states. It may be timely for the international community to step up discussions on the concept of burden sharing, particularly users, to take greater notice of the discussions. After all, safe and unimpeded navigation does not only satisfy the environmental concerns of the littoral states but provides an economic advantage for vessels transitting the Straits.

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¹¹ Sakura Institute of Research, Research on Traffic Flows in the Straits of Malacca and Singapore – Estimating the Impact of the Asian Currency Crisis on Shipping Traffic in the Malacca and Singapore Strait, 1999.

¹² The first conference was held in Singapore on 23rd September 1996 and a follow up conference on 14th and 15th October 1999.